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Earth Space Systems Science

Unit 6: The Biosphere

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DRAFT

The Coordinator of Science, Anne Arundel County Public Schools, Maryland would appreciate notification if you plan to use all or any of this educational product at rtshelli@clark.net.

Earth/Space Systems Science
Unit 6: The Biosphere

Description

The biosphere refers to the living and dead organic material on planet Earth. This unit helps students to begin to examine the interactions of the biosphere with the other spheres: the atmosphere, the hydrosphere, the geosphere, and the space sphere.

There is continuous cycling and rearrangement of atoms that make up the matter of the universe. This matter is made of both living and nonliving material. Through chemical reactions, different compounds and substances are formed and energy is either used or released.

Of importance in understanding the biosphere are topics such as the global water and energy cycle, climate variability and its impact, biogeochemistry (in particular the global carbon cycle). Also important are the dynamics of natural ecosystems and human impact on such systems (such as vegetation, soils, and atmospheric interactions), ocean biology, and computer and numerical modeling of these complicated systems.

Applications stemming from the understanding of the biosphere and its interrelationships within the earth-space system include aquaculture and agriculture, use of natural resources, implications of natural hazards, environmental quality, environment and human health, and urban infrastructure.

Key questions for this unit are:

1. What determines how chemical reservoirs respond to imbalances in the flow of materials to them?
2. How does matter move through the Earth's reservoirs and what is the role of energy?
3. What is the impact of living organisms and dead organic matter on the Earth's systems and how do the Earth's systems impact living things?

Key Concepts

· The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere and organisms as part of geochemical cycles. (NSES p.189)

· Movement of matter between reservoirs is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. (NSES, p. 189)

- Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all other elements. (NSES, p. 190)

- The stars differ form each other in size, temperature, and age, but appear to be made up of the same elements that are found on the earth and to behave according to the same physical principals. (AAAS, p. 65)

- Evidence for one-celled forms of life- the bacteria-extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of the Earth's atmosphere, which did not originally contain oxygen. (NSES, p. 190)

- The amount of life any life can support is limited by the available energy, water, oxygen, and minerals, and by the availability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land. (AAAS, p. 121)

- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes and the change may be detrimental.

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Earth/Space Systems
*Sc*ience Instruction

1. What do students need to know or be able to do to understand events across spheres (subsystems of the Earth-space systems)?

5. Student Project for each sphere: analyze another event following modeling by the teacher of the exemplar event

Energy Balance/Conservation of Energy

Mass Balance/Conservation of Mass

Events

- What are some "events" that occur?
- events drive the system
- events happen when the system gets out of balance
- events help the system get back into balance

How do the systems and subsystems of each sphere behave and interact?

- atmosphere
- biosphere
- hydrosphere/cryosphere
- geosphere
- space sphere

2. What do we need to know to understand systems?

- parts/components (i.e. reservoir of matter or energy)
- state of the system or set of attributes that characterize a system (i.e. sea surface temperature)
- links between/among components (reflectivity of a surface [albedo] and surface temperature)
- feedback loops
- system in equilibrium (and stable and unstable conditions)
- how a system responds to disturbances (i.e. effects of volcanic eruption on climate)

3. What are the tools that help us understand the spheres?

- remote sensing
- modeling
- observational networks
- system diagram or flow chart or concept map
- graphs and graph-making
- computer as an analysis tool

4.Track an event throughout the course to model intera***ctions for students.***
How does the event impact each sphere?
How do each of the other spheres impact the event?

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CONTENT OUTLINE

THE BIOSPHERE

I. Connecting the Biosphere to the Earth-Space System
   A. Hydrosphere: Net Primary Productivity
   B. Atmosphere, Geosphere, Biosphere, Hydrosphere, Space Sphere: The Carbon Cycle
   C. Space Sphere: Analysis of Chemical Elements
   D. Atmosphere: Impact of Environment on an Organism
   E. Atmosphere: Impact of Evolution of Life on Earth (supplemental)
   F. Earth-Space System: Impact of Seasons on Climate

II. Environmental Impact on the Biosphere
   A. Greenhouse Gases and Climate
   B. Climate - Creating an Action Plan

III. Analysis of a Biosphere Subsystem within the Earth/Space System

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Science Core Learning Goals

Goal 1: Skills and Processes

The student will demonstrate ways of thinking and acting inherent in the practice of science. The student will use the language and instruments of science to collect, organize, interpret, calculate, and communicate information.

Expectation 1.1
The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.
Indicators
1.1.1 The student will recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues.
1.1.2 The student will modify or affirm scientific ideas according to accumulated evidence.
1.1.3 The student will critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.

Expectation 1.2
The student will pose scientific questions and suggest experimental approaches to provide answers to questions.
Indicators
1.2.1 The student will identify meaningful, answerable scientific questions.
1.2.2 The student will pose meaningful, answerable scientific questions.
1.2.3 The student will formulate a working hypothesis.
1.2.4 The student will test a working hypothesis.
1.2.5 The student will select appropriate instruments and materials to conduct an investigation.
1.2.6 The student will identify appropriate methods for conducting an investigation and affirm the need for proper controls in an experiment.
1.2.7 The student will use relationships discovered in the lab to explain phenomena observed outside the laboratory.

Expectation 1.3
The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.
Indicators
1.3.3 The student will demonstrate safe handling of the chemicals and materials of science.

Expectation 1.4
The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.

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Indicators

1.4.1 The student will organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title).
1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions.
1.4.3 The student will use experimental data from various investigators to validate results.
1.4.5 The student will check graphs to determine that they do not misrepresent results.
1.4.6 The student will describe trends revealed by data.
1.4.8 The student will use models and computer simulations to extend his/her understanding of scientific concepts.
1.4.9 The student will use analyzed data to confirm, modify, or reject an hypothesis.

Expectation 1.5

The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.

Indicators

1.5.1 The student will demonstrate the ability to summarize data (measurements/observations).
1.5.2 The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.
1.5.4 The student will create and/or interpret graphics (scale drawings, photographs, digital images, etc.).
1.5.6 The student will read a technical selection and interpret it appropriately.
1.5.7 The student will describe similarities and differences when explaining concepts and/or principles.
1.5.9 The student will communicate conclusions derived through a synthesis of ideas.

Expectation 1.6

The student will use mathematical processes.

Indicators

1.6.1 The student will use ratio and proportion in appropriate situations to solve problems.
1.6.2 The student will use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
1.6.3 The student will express and/or compare small and large quantities using scientific notation and relative order of magnitude.
1.6.4 The student will manipulate quantities and/or numerical values in algebraic equations.
1.6.5 The student will judge the reasonableness of an answer.

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Expectation 1.7

The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.

Indicators

1.7.1 The student will apply the skills, processes, and concepts of biology, chemistry, physics, and earth science to societal issues.
1.7.2 The student will identify and evaluate the impact of scientific ideas and/or advancements in technology on society.
1.7.4 The student will recognize mathematics as an integral part of the scientific process.
1.7.5 The student will investigate career possibilities in the various areas of science.
1.7.6 The student will explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.

Goal 2: Concepts of Earth/Space

The student will demonstrate the ability to use scientific skills and processes (Core Learning Goal 1) to explain the physical behavior of the environment, earth, and the universe.

Expectation 2.2

The student will describe and apply the concept of natural forces in the study of Earth/Space Science.

Indicators

2.2.1. The student will explain the role of natural forces in the universe.
At least – formation of planets, orbital mechanics, stellar evolution.
2.2.2. The student will explain the role of natural forces in the earth.
At least – retention of an atmosphere, an agent of erosion and deposition, tides and deep ocean currents

Expectation 2.3

The student will explain how the transfer of energy affects weather and climate.

Indicators

2.3.1. The student will describe heat transfer systems in the atmosphere, on land, and in the oceans.
At least – convection, conduction, radiation from space and from within Earth
2.3.2. The student will investigate meteorological phenomena
At least – hurricanes, tornadoes, floods, thunderstorms, blizzards

2.3.3. The student will research topics of current concern with regard to climate.
At least – greenhouse effect, global warming (or cooling), ocean currents

Expectation 2.5

The student will know how to connect prior understanding and new experiences to evaluate natural cycles.

Indicators

2.5.1. The student will investigate various physical cycles found in the natural world.
At least – rock cycle, water cycle, tides, lunar phases, eclipses, seasons

2.5.2. The student will analyze the effects of natural cycles on human activity.
At least – weathering, erosion and deposition, agriculture, aquaculture

Expectation 2.6

The student will investigate how the political climate affects the development of a scientific theory or model.

Indicators

2.6.2 The student will research the change in the belief in the age of the earth.
At least – fossil record, rock layers, radioactive dating, Big Bang theory

Expectation 2.7

The student will know how to use measurement of different orders of magnitude to construct an earth science model.

Indicators

2.7.1. The student will create a geologic time scale including eras, periods, and epochs.
At least – analogies, ratios, scale drawings, powers of ten

2.7.2. The student will create a geologic time scale including eras, periods, and epochs.
At least – analogies, ratios, scale drawings, powers of ten

2.7.3. The student will construct a model to show human's place in the time continuum.

Expectation 2.8

The student will know how to investigate an earth science issue to develop an action plan.

Indicators

2.8.1. The student will investigate an issue such as climatic changes or electric power generation

2.8.2. The student will identify data that are biased.

2.8.3. The student will use tables, charts, and graphs in making oral and written presentations.

2.8.4. The student will know why curiosity, honesty, openness, and skepticism are highly regarded in science.

2.8.5. The student will understand that real problems have more than one solution, and the decisions to accept one solution over another are made on the basis of many issues.

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SCIENCE RUBRIC

LEVEL 4

There is evidence in this response that the student, using analysis, has a full and complete understanding of the question or problem.

- The student has synthesized information to provide a correct answer.
- The supporting evidence consists of an integration of ideas.
- The student has effectively applied the information to a practical problem in a related area of science, mathematics, or technology.
- The response is enhanced through the use of accurate terminology to explain scientific principles.

LEVEL 3

There is evidence in this response that the student, using analysis, has a good understanding of the question or problem.

- The student has synthesized information to provide a correct answer.
- The supporting evidence is complete.
- The student has applied the information to a practical problem within the particular concept area of science.
- The response uses mostly accurate terminology to explain scientific principles.

LEVEL 2

There is evidence in this response that the student has a basic understanding of the question or problem.

- The student provides a correct answer.
- The supporting evidence is only moderately effective.
- The student has applied the information to a practical problem within the scope of the question.
- The response uses limited accurate terminology to explain scientific principles.

LEVEL 1

There is evidence in this response that the student has some understanding of the question or problem.

- The student provides a partially correct answer.
- The supporting evidence is only minimally effective.
- The student has attempted to apply the information.
- The response makes little or no use of accurate terminology to explain scientific principles.

LEVEL 0

There is evidence that the student has no understanding of the question or problem.

- The response is completely incorrect or irrelevant, or there is no response

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Scoring Criteria for Graphs

The student will organize data appropriately using a graph.

Level 4
Data are accurately plotted (90-100%) and the graph includes nine of the ten elements.

Level 3
Data are accurately plotted and the graph includes seven of the ten elements,
OR
data are mostly accurate (80-89%) and the graph includes nine of the ten elements.

Level 2
Data are accurately plotted and the graph includes five of the ten elements,
OR
data are generally accurate (70-79%) and the graph includes seven of the ten elements.

Level 1
Data are accurately plotted and the graph includes three of the ten elements
OR
Data are somewhat accurate (60-69%) and the graph includes five of the ten elements.

Level 0
Data are inaccurately plotted (<60%) or the graph includes fewer than five elements.

ELEMENTS OF THE GRAPH

- Appropriate title
- X-axis labeled correctly with appropriate quantities/variables
- X-axis labeled correctly with appropriate units
- Appropriate intervals indicated on the X-axis
- Given the length of axes on the grid, the scale is appropriate for the range of data
- Y-axis labeled correctly with appropriate quantities/variables
- Y-axis labeled correctly with appropriate units
- Appropriate intervals indicated on the Y-axis
- Given the length of axes on the grid, the scale is appropriate for the range of data

Origin correctly identified

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Lesson Planning Organizer

Lesson	Topic	Approximate 45 Minute Class Periods	Outcomes
1	Primary and Secondary Productivity	2-3	Investigate the influence of light on rate of primary productivity by measuring productivity of phytoplankton in the laboratory; predict patterns of global productivity by analyzing the relationship among factors that influence primary productivity.
2	The Role of the Carbon Cycle in the Biosphere	1-2	Illustrate the role of the carbon cycle within the biosphere by developing a mathematical model of balance within the carbon cycle system.
3	Connecting the Biosphere to the Earth/Space System: Chemical Abundance in the Solar System	2	Compare the abundance of chemical elements in the Earth-Space system by analyzing satellite data; describe how technologies used to study the universe provide data for understanding the formation of the solar system and galaxy.
4	Where's Phyto?	2-3	Diagram the interrelationships between phytoplankton and changes in the envi-

			ronment by interpreting composite data images; explain how the cause of seasons impacts various regions of the biosphere.
5	SEASONAL IMPACT ON GLOBAL CLIMATE	1-2	Compare seasonal climate data by using data-visualization software.
6	GREENHOUSE GASES AND CLIMATE	1-2	Relate temperature changes to gas level changes by analyzing data; explain the effect of human activity on the amount of greenhouse gas in the atmosphere, and its effect on Earth's climate.
6A	IMPACT OF EVOLUTION OF LIFE ON THE ATMOSPHERE		To be developed
7	FINDING A BALANCE– THE EVERGLADES	2	Create an action plan to address drought in the Everglades by examining factors that affect this subsystem of the biosphere.
7A	IMPACT OF EL NIÑO ON THE BIOSPHERE	1-2	To be developed
8	ANALYZING A SUBSYSTEM OF THE BIOSPHERE AS AN EARTH SYSTEM	2+ (may be continued into next unit)	Analyze a specific subsystem of the biosphere and how it relates to other Earth systems by creating a systems diagram.
Approximate Number of Class Periods		**15**	

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Lesson 1: Primary and Secondary Productivity

Estimated Time: Two to three forty-five minute class periods

Indicator(s) Core Learning Goal 1:

1.2.7 The student will use relationships discovered in the lab to explain phenomena observed outside the laboratory.

1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions.

Indicator(s) Core Learning Goal 2:

2.2.2. The student will explain the role of natural forces in the earth.
At least – retention of an atmosphere, an agent of erosion and deposition, tides and deep ocean currents

Student Outcome(s):

1. The student will be able to investigate the influence of light on rate of primary productivity by measuring productivity of phytoplankton in the laboratory.
2. The student will be able to predict patterns of global productivity by analyzing the relationship among factors that influence primary productivity.

Brief Description:

This lesson helps students make significant connections between the atmosphere, biosphere and the hydrosphere by focusing on productivity. It begins with a student-designed experiment to determine primary productivity by measuring oxygen production. Students are then asked to make connections to what they have learned about upwelling and all the factors that might lead to mixing of seawater. At the end of this learning activity, students should create a systems diagram the interplay of the three Earth spheres and the various subsystems.

Background knowledge / teacher notes:

Ask students to bring in any underwater photographs they may have. You need good colorful ones, taken with a flash AND blue-gray drab ones, taken without a flash.

<u>GT Extension</u>:
SEASONAL GLOBAL PRIMARY PRODUCTION MAPS. Available:
http://marine.rutgers.edu/opp/swf/Production/results/all2_swf.html

World image maps may take up to 5 minutes to load. The color scale map must be used in conjunction with the world data image map.

Lesson Description:

ENGAGE	*Vocabulary: primary productivity, cellular respiration, photosynthesis, phytoplankton.* Ask students to brainstorm what is meant by the biosphere (all the living organisms and dead organic material). Post as a working definition. Show students a picture of a transparent sealed jar containing a plant and an animal. Ask students to explain why both organisms are able to survive in this closed environment. Review the relationship between photosynthesis and cellular respiration. [Use the equations for both of these processes so that students will be able to make a connection to the carbon cycle in subsequent lessons.] Generate a list of the conditions and materials necessary for photosynthesis.
EXPLORE	Primary productivity may be defined as the amount of organic material produced by photosynthesis. (Prentice Hall (1999). The Earth System. p. 133). In this activity, students will use the amount of dissolved oxygen produced as a measure of primary productivity. Part One ***Journal Write***: Students will design a laboratory investigation to determine the influence of light on the rate of primary productivity by measuring the amount of dissolved oxygen produced. Provide students with the following materials: two test tubes with caps/corks, phytoplankton (Euglena), graduated cylinder, light source, dissolved oxygen test kit or DO meter, test tube rack, grease pencil, dark construction paper, scissors, and tape. Experiment will need to run over night. **MAKE SURE STUDENTS RECORD INITIAL DISSOLVED OXYGEN DATA FOR BOTH TEST TUBES.** *Accommodation: Provide guidance for students in the design of the lab.* Part Two Once the experiment is set up, discuss with students how water affects light with increasing depth. Ask if any of the students have ever gone scuba diving. Have them describe how colors change with depth. Show underwater pictures taken with and without a flash. Those

	without a flash will be blue-gray and drab because less light is penetrating. Discuss how marine plants/phytoplankton have adapted to poor light conditions. ***Journal Write***: Have students write a hypothesis explaining the relationship between light, depth and primary productivity. *Accommodation: Provide a sentence starter for students who need that support.*
EXPLAIN	On the second day, students will measure the dissolved oxygen content again. Data should be recorded in the journal. **Laboratory Analysis** Since we know the amount of dissolved oxygen in each test tube at the beginning of the experiment and after 24 hours, we can determine the rate of photosynthesis/primary production. Gross productivity = total amount of dissolved oxygen present in the LIGHT test tube at the end of 24 hours. Net productivity = Gross productivity minus the amount of oxygen used in cellular respiration Example Light Dark Dissolved Oxygen 8 ppt 8 ppt START 8 ppt 2 ppt 24 hours Gross productivity = 8 6 ppt lost due to cellular respiration Net productivity = 8-6 = 2 ***Journal Write***: 1. What is the gross productivity for the light test tube? 2. What is the net productivity? 3. Based on your results, explain how depth influences primary productivity. 4. In the natural world, we cannot increase the amount of light plants receive. Suggest other methods we use to increase productivity
EXTEND	View *Biosphere, Jan. 1999*. Available: http://bromide.ocean.washington.edu/cbp_home/teaching/seawifs.html to compare student results to a actual map of ocean and land productivity. Go to GSFC *First Image of the Global Biosphere*. Available: http://asd-www.larc.nasa.gov/biomass_burn/globe.html Teacher will refer to the above map depicting the global distribution of productivity. Ask students to describe areas of upwelling and mixing of waters. Remind students that these waters are nutrient rich. How

	would this influence ocean productivity? ***Journal Write:*** Students will write a paragraph using the following scenario: You have inherited an ocean-going fishing vessel. In order to maximize your profits, you need to gather as many fish as possible in the shortest amount of time. Using your knowledge of factors that influence ocean productivity, where in the world will you go to fish and why? *Accommodation: Provide a graphic organizer that helps students to organize ideas. It should contain space for the opinion (where will you fish?), reasons for that choice and evidence to support those reasons. The AREST organizer used for persuasive writing might be a good choice.* GT Connection: Ask students to hypothesize ocean productivity based on the seasons. Compare student predictions of productivity in different seasons to actual worldwide data available in dramatic image maps. *Seasonal Primary Production Color Scale.* Available: http://marine.rutgers.edu./opp/swf/Production/gif_files/ColorBarSeason150.gif Example of *World Productivity Image Map*. Available: http://marine.rutgers.edu./opp/swf/Production/gif_files/PP_9906_9908B.gif Mathematics/GT Connection: investigate the use of algorithms in scientific missions.
EVALUATE	Students will share their paragraphs, written in the **EXTEND** portion of this lesson. They should compare the locations chosen, and defend their rationale for making these choices. In addition, they should note similarities in their paragraphs, noting how many students selected the same regions. ***Journal Write***: 1. What are the characteristics of a region that will experience high productivity? 2. Using the data from your experiment, describe the relationship between light and productivity. 3. Construct a systems diagram to illustrate the factors that impact productivity. Include factors from each of the spheres. 4. Write a short paragraph to explain your systems diagram.

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Materials:

Two test tubes with caps/corks
Phytoplankton (Euglena) [available from Carrie Weedon Science Center]
Graduated cylinder
Light source
Dissolved oxygen test kit or DO meter
Test tube rack
Grease pencil
Dark construction paper
Scissors
Tape
World map showing upwelling/productivity
Underwater photographs supplied by students (requested in advance)

Resources:

Biosphere, January 1999. Available:
http://bromide.ocean.washington.edu/cbp_home/teaching/seawifs.html
From GSFC NASA's global ocean color monitoring mission called SeaWiFS.

Freeman. (2000). Laboratory Exercises in Oceanography, "Primary and Secondary Productivity"

GSFC. *First Image of the Global Biosphere*. Available:
http://asd-www.larc.nasa.gov/biomass_burn/globe.html
An illustration of the global biosphere is part of NASA Goddard Space Flight Center's program of Earth-science research. It shows, for the first time, the patterns of plant life both on the land and in the oceans as observed from space. The illustration was produced by combining data from two different satellites and shows Earth as a complex system, teeming with life. Students may click on specific areas of the map for greater detail.

MODIS OPP/SCF: Overview. Available:
http://opp.gsfc.nasa.gov/
This is an excellent text document that might serve as a technical reading for student. Topics include:

- What is Phytoplankton Primary Productivity?
- Why is Productivity Important?

and a discussion of research and development activities.
From the Moderate Resolution Imaging Spectroradiometer (MODIS) Ocean Primary Productivity (OPP) Working Group at Goddard Space Flight Center.

SEASONAL GLOBAL PRIMARY PRODUCTION MAPS. Available:

http://marine.rutgers.edu/opp/swf/Production/results/all2_swf.html
World image maps may take several minutes to load. This data in the form of dramatic world images is provided by *Ocean Primary Productivity Study*. Rutgers, The State University of New Jersey Institute of Marine and Coastal Sciences.

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Lesson 2: The Role of the Carbon Cycle in the Biosphere

Estimated Time: One to two forty-five minute class periods

Indicators(s): Core Learning Goal 1

1.4.4 The student will determine the relationships between quantities and develop the mathematical model that describes these relationships.

Indicators(s): Core Learning Goal 2

2.5.1. The student will investigate various physical cycles found in the natural world.
At least – rock cycle, water cycle, tides, lunar phases, eclipses, seasons

2.5.2. The student will analyze the effects of natural cycles on human activity.
At least – weathering, erosion and deposition, agriculture, aquaculture

Student Outcome(s):
The student will be able to illustrate the role of the carbon cycle within the biosphere by developing a mathematical model of balance within the carbon cycle system and completing a systems diagram.

Brief Description:
In this lesson, students will make the connection between productivity and geochemical cycles-specifically the carbon cycle.

Background knowledge / teacher notes:
The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere and organisms as part of geochemical cycles. (NSES p.189)

Movement of matter between reservoirs is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. (NSES, p. 189)

In biogeochemical cycling models, elements and compounds are portrayed in boxes. Examples of reservoirs on a global scale are each of the spheres including the atmosphere, the hydrosphere, the geosphere, and the biosphere.

To construct systems diagrams, one should define the boundaries of the system and any subsystems (the reservoirs), predict the flow of materials along a pathway (arrows), think about any fluxes or changes to the system, and include mathematical modeling using provided or researched data.

Lesson Description:

ENGAGE	Have students read the article *Modeling Earth's Land Biosphere.* Available: http://earthobservatory.nasa.gov:81/Study/Modeling/biosphere_modeling.html Have students review the meaning of net primary productivity.
EXPLORE	Have students compare the three color computer-generated maps at the above site, each produced by a different computer model. In groups, discuss the importance of understanding the exchange of carbon dioxide between the biosphere and the atmosphere. Discuss the impact of other factors mentioned in the article. *Accommodation: Students should read the discussion points before reading the article. If the article were printed, students could highlight ideas they will need for the discussion.* GT Connection: *Why Build Computer Models?* Available: http://earthobservatory.nasa.gov/Study/Modeling/biosphere_modeling_2.html Discuss with students the advantages and disadvantages of computer modeling.
EXPLAIN	***Journal Write***: 1. Sketch a systems diagram that shows the relationship between carbon dioxide, photosynthetic plants, the atmosphere and hydrosphere, and the biosphere. 2. Add on additional factors that may impact on primary productivity. 3. Where will global climate change connect to this systems diagram? 4. Explain the importance of carbon in this systems diagram. If you remove the carbon, what happens to productivity?
EXTEND	1. Discuss with students the concepts that there is continuous cycling and rearrangement of atoms that make up the matter of the universe. This matter is made of both living and nonliving material. Through chemical reactions, different compounds and substances are formed and energy is either used or released. 2. Have students brainstorm the different places carbon is found in the earth system - either as carbon or a carbon compound. 3. Read about the carbon sources and sinks. Exploring the Environment. Earth on Fire. *Carbon Cycle.* Available: http://davem2.cotf.edu/ete/modules/carbon/efcarbon.html

	Accommodation: Providing a copy of the diagram for each student would aid students' understanding of the article since students could read the article and quickly refer to the diagram when needed. 4. Click on the diagram to examine details of the cycle. 5. Explain what is meant when the carbon cycle is described as a "closed system." 6. Use the information in the diagram to "balance" the carbon cycle by creating a mathematical model based on a systems diagram. Given the amount of carbon moving between the various sinks, as listed on the process arrows, what change is occurring in the various carbon sinks? Are they increasing, decreasing, or remaining constant? Be sure to include the uncertainties in your calculations. Remember that the carbon cycle is a closed system, so all the carbon must be accounted for. It cannot disappear. *Accommodation: The teacher may need to use modeling and guidance as students develop their mathematical model.*
EVALUATE	1. Share mathematical models among the groups. 2. Where in the model is carbon unaccounted? 3. Ask students to compare their analysis to that of other groups. 4. ***Journal Write***: Describe an "event" that would change the amount of carbon in a particular reservoir and explain your reasons. Add the event to your systems diagram. *Modification: Give the students a list of events that would change the amount of carbon in a particular reservoir. Students would describe the event and explain the reasons.* <u>GT Connection</u>: Assign student groups to research and construct systems diagrams for the other major biogeochemical cycles: nitrogen, phosphorus, sulfur, and oxygen. Combine all information to construct a summary diagram of the biogeochemical cycles of the key elements.

Materials:
Computer with Internet Access

Resources:
<u>Exploring the Environment. Earth on Fire</u>. *Carbon Cycle*. Available:
http://davem2.cotf.edu/ete/modules/carbon/efcarbon.html

Exploring the Environment. Earth on Fire. *Glossary.* Available:
http://davem2.cotf.edu/ete/modules/carbon/efglossary.html

Modeling Earth's Land Biosphere. Available:
http://earthobservatory.nasa.gov/Study/Modeling/biosphere_modeling.html

Prentice Hall (1998). Our Changing Planet. *Carbon.* pp. 160-166.
Figure 5.3 is a systems diagram of the major reservoirs and flows of the biogeochemical cycle of carbon.

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Lesson 3: Connecting the Biosphere to the Earth/Space System: Chemical Abundance in the Solar System

Estimated Time: Two forty-five minute class periods

Indicators(s): Core Learning Goal 1

1.1.2 The student will modify or affirm scientific ideas according to accumulated evidence.
1.5.5 The student will use computers and/or graphing calculators to produce tables, graphs, and spreadsheet calculations.
1.6.3 The student will express and/or compare small and large quantities using scientific notation and relative order of magnitude.
1.7.5 The student will investigate career possibilities in the various areas of science.

Indicators(s): Core Learning Goal 2

2.1.1. The student will describe current efforts and technologies used to study the atmosphere, land, and oceans of the Earth.
At least – remote sensing from space, undersea exploration, seismology, weather data collection
2.1.2. The student will describe current efforts and technologies used to study the universe.
At least – optical telescopes, radio telescopes, spectroscopes, satellites, space probes, manned missions.
2.2.1. The student will explain the role of natural forces in the universe.
At least – formation of planets, orbital mechanics, stellar evolution.

Student Outcome(s):

1. The student will be able to compare the abundance of chemical elements in the Earth-Space system by analyzing data from satellites.
2. The student will be able to describe how technologies used to study the universe provide data for understanding the formation of the solar system and galaxy.

Brief Description:

This lesson is based on the NASA Ambassador Investigation, *Comparing Elemental Abundance*
Available: http://edmall.gsfc.nasa.gov/99invest.Site/ACE/CoElAb.abstract.html
written by Daniel Hortert, GESSEP Program, and Bennett Seidenstein, GESSEP Program. Dr. Eric R. Christian is the ACE Deputy Project Scientist and Beth Jacob is the ACE Outreach Specialist.

Students have completed a description of the carbon biogeochemical cycle. In this lesson, students will be asked to look for elemental connections between the Earth system and its subsystem the biosphere, and the Space Sphere by using data collected by the ACE spacecraft.

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The student will access ACE spacecraft data, become proficient at using the ACE Data Interface to access ACE data, and will learn how to read logarithmic graphs. The student will be able to research ACE data sets to look for correlation between available particle fluxes for some selected solar events. The student will access ACE spacecraft data describing the ratio of He^{++} to H+ ions as measured in the solar wind and will compare that data to electron and proton fluxes (changes) measured by ACE. Students will also compare the solar wind ratio to the ratio of He^{++} to H^{+} ions in the matter found in the Sun. The student will compare elemental abundances found in the Earth to elemental abundances found in the Sun and in the solar wind as measured by the ACE spacecraft.

Background knowledge / teacher notes:
How does the Earth System and its subsystem, the biosphere relate to the universe?

Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all other elements. (NSES, p. 190)

The stars differ form each other in size, temperature, and age, but appear to be made up of the same elements that are found on the earth and to behave according to the same physical principals. (AAAS, p. 65)

<u>The ACE Mission</u>
According to the Science Goals of the ACE Mission, (http://www.srl.caltech.edu/ACE/ace_mission.html#science), the primary purpose of the Advanced Composition Explorer (ACE) is to determine and compare the isotopic and elemental composition of several distinct samples of matter. These samples include the solar corona, the interplanetary medium, the local interstellar medium, and Galactic matter.

The nine scientific instruments on ACE are performing:

1. Comprehensive and coordinated composition determinations
   - Elemental
   - Isotopic
   - Ionic charge state
2. Observations spanning broad dynamic range
   - Solar wind to galactic cosmic ray energies
   - (~100 eV/nucleon to ~500 MeV/nucleon)
   - Hydrogen to Zinc (Z = 1 to 30)
   - Solar active and solar quiet periods
3. Investigations of the origin and evolution of solar and galactic matter
   - Elemental and isotopic composition of matter

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- Origin of the elements and subsequent evolutionary processing
- Formation of the solar corona and acceleration of the solar wind
- Particle acceleration and transport in nature

In this lesson, students will explore some of these connections. Although the procedures may seem complicated for working with the data interface on the web site, students will be following step by step instructions.

One of the fundamental questions facing astronomers and astrophysicists is the origin of the elements that make up the universe around us. This investigation provides an opportunity to use data collected by scientists who work on answering that question.

In the investigation the learner will

1. Access Advance Composition Explorer (ACE) data to look for a correlation with known solar events.
2. The student will access ACE /SWEPAM data to determine if there is a correlation between the ratio of He^{++} to H^{+} ions as compared with electron and proton fluxes (rates of particle flow). The ratio of He^{++} to H^{+} found in the solar wind will also be compared to the ratio of He^{++} to H^{+} found in the Sun.
3. The student will compare the relative abundance of elements found in the Earth as a whole, to those found in the Sun, and to those found in the solar wind.

Reprinted and adapted from *Abstract.* Available:
http://edmall.gsfc.nasa.gov/99invest.Site/ACE/CoElAb.abstract.html

The relative abundance of the elements found in the Earth as a whole are shown in the following table.

ELEMENTAL ABUNDANCE IN THE EARTH

ELEMENT	ABUNDANCE: % BY MASS
Iron	35
Oxygen	30
Silicon	15
Magnesium	13
Nickel	2.4
Sulfur	1.9
Calcium	.1
Aluminum	1.1
Other	<1

(From *Background*. http://edmall.gsfc.nasa.gov/99invest.Site/ACE/CoElAb.html#background)

For an explanation of logarithmic plots access *Introduction to Multiplication and Division by Logarithmic Algebra.* Available:

http://mentor.lscf.ucsb.edu/mcdb108a/tw-lig/logarithmic-algebra.htm

Lesson Description:

ENGAGE	Discuss with students and list the main biogeochemical cycles. Ask students where such elements are found in the biosphere. What are the reservoirs in the other earth system spheres? Ask students to think about similarities of the Earth System to other celestial bodies. What do we know about the elements found throughout the universe? Students may refer to nuclear fusion of hydrogen to helium in the sun. Help students extend the concept by doing a concept map for students. Illustrate : stars _ condensed by gravity from clouds of molecules of light elements _ formed heavier elements by process of nuclear fusion _ nuclear fusion released great amounts of energy over millions of years _ some stars exploded _ produced clouds of heavy elements from which other stars and planets could later condense. (AAAS, p. 65) In this lesson we will examine some direct evidence to connect the Earth System and its subsystem, the biosphere to the Space Sphere. Introduce students to the ACE Project. *Advanced Composition Explorer (ACE) Mission Overview.* Available: http://www.srl.caltech.edu/ACE/ace_mission.html and associated Science Goals. See teacher notes on the ACE Mission Science Goals above.
EXPLORE	Part I: Practice Working with the Data Access the ACE Project Page at http://helios.gsfc.nasa.gov/ace/ace.html Adaptive strategy: Some students will need to have this modeled by the teacher or be paired with a peer helper. Chunking the directions into smaller groups may also be of assistance to students. 1. Click the Online Data button. 2. Click the Browse button in the section for Online Data. 3. At this point you have a choice of which ACE data sets you want to access. Under the Flexible Browse Data Interface you will find a window which can be used to choose which days you want to access. To familiarize you with how to select the data sets we will look initially at some data showing all of the ACE data . In the win-

dow select the Browse Data All category and then click GO.

4. In the next window click on ACE Browse Daily Averages.
5. In the next window you will have options available regarding which ACE instruments you want to select, which particle you want to select, what energy ranges you want to select, and whether you want to observe logarithmic or linear plots. To begin we will look for correlation between ACE data and two well documented events that occurred on the Sun. The day corresponding to the first event was November 6, 1997. Click in the box to the right of SIS corresponding with Z > 9 9-21. This means that you will view data from the SIS instrument on ACE and will see a plot of particles detected that had an atomic number greater than 9 (heavier than fluorine) and had energies from 9-21 MeV (million electron volts) per nucleon (proton or neutron). Next to the Y-axis Scaling choose Linear. Now you are ready to plot the data set that you have selected.
6. Under Choose Data Format click on the Retrieve data button.
7. Since the ACE data time axis is shown in terms of DOY (day of year) you will need to know that November 6, 1997 was day 310 of that year. Each block of time on the x-axis represents 25.6 days. Do you see a peak in the SIS data at a place on the graph matching day 310?
8. Close the window that shows the plot and click Reset Form.
9. Again select SIS data for Z > 9 9-21 but this time select Logarithmic rather than Linear and click on the Retrieve data button.

Accommodation: Students will need clear directions in written form. Providing a printed copy of the web page with areas to be clicked highlighted will be helpful to the students.

<u>More Practice</u>

Another solar event on record occurred during a two day period in early May of 1998 corresponding with DOY 121-122 of 1998. Use the procedure learned above to determine if the ACE data shows this event in both the linear and logarithmic graphs.

If you close the window, which shows the plot, and then click back twice on your browser you can again select which ACE data sets you want to access (as you did above).

For this part of the investigation go to the window under the Flexible Browse Data Interface and choose a smaller range of days to access. Click GO.

EXPLAIN	***Journal Write***: 1. How does the logarithmic graph differ from the linear graph? Does this graph peak on day 310? 2. What is the actual reading for the number of particles/cm^2/sec? HINT : The y-axis is shown as a logarithmic plot. The 10^{-8} at the bottom of the y-axis corresponds with a particle flux (rate of particle flow) of 1 X 10^{-8} . The next small line (going up the) axis corresponds with 2 X 10^{-8}, then 3 X 10^{-8}, and so on. When you get to the line labeled 10^{-7}, the particle flux has now increased to 1 X 10^{-7}. A particle flux corresponding to this line is ten times higher than a flux corresponding with the 1 X 10^{-8} found at the bottom of the chart. Each increase on the chart of one power of ten is said to be an increase in magnitude of one. For example, a flux of 10^{-1} is said to be five orders of magnitude above a flux of 10^{-6}. <u>From More Practice</u>: 1. What is the actual reading for the number of particles/cm^2/sec for that portion of the logarithmic graph? 2. Did this event produce a larger or smaller particle flux than the November 1997 event? 3. Investigate a variety of instruments and a variety of particle types. Construct a data table which includes the following: ▪ A list of days, which you believe must have had energetic solar events, based on peaks found in your research. ▪ A list of ions or elements which seem to be unaffected by the solar energetic events (if any). A list of the elements that are measured by ACE and are also found in the equations for the PP, and CNO cycles found in the *NASA Educational Brief: Fusion & Nucleosynthesis*. Available: http://edmall.gsfc.nasa.gov/99invest.Site/science-briefs/ace/ed-fusion.html
EXTEND	Part II: Access the *ACE Project Page*. Available: http://helios.gsfc.nasa.gov/ace/ace.html 1. Click the Online Data button. 2. Click the Browse button in the section for Online Data. 3. In the Flexible Browse Data window select the Browse Data All category and then click GO. 4. In the next window click on ACE Browse Daily Averages. 5. In the next window click in the box to the right of SWEPAM corre-

	sponding with Helium ratio. Next to the Y-axis Scaling choose Logarithmic. 6. Now you are ready to plot the data set, which you have selected. Under Choose Data Format click on the Retrieve data button. This graph provides data showing the DOY vs. the ratio of He^{++} to H^{+} ions as measured in the solar wind. ***Journal Write***: Analyze the plot and make a data table that contains the following columns: DOY, year, numerical value of the ratio, and the order of magnitude. Include in your data table information for the three highest and the three lowest ratios that you observe. 1. Does the number of helium and hydrogen ions seem to remain constant? 2. If not, what is the difference in the order of magnitudes for the high and low values? 3. Do the days with the highest ratios match up with any of the solar events that you investigated in Part One of this investigation? Justify your answer. 4. Does the helium ratio correspond with the fluxes of any of the particles measured on other ACE instruments? 5. To determine your answer, close the window that shows the plot and then click Reset Form, and then select the following: EPAM e-38-53, SIS H E > 10, and SWEPAM corresponding with Helium ratio. 6. Under Choose Data Format click on the Retrieve data button. 7. Now you have a graph that superimposes the three sets of data to be analyzed. 8. Access the data table containing information on **ELEMENTAL ABUNDANCE IN THE SUN** found in the *Background* for this investigation. (See teacher background) 9. Use the column labeled % by NUMBER and write down the % for helium and the % for hydrogen as shown in the table. *Accommodation: Provide the data table and model the process of entering data.* ***Journal Write***: 1) Calculate the ratio of He to H and write down that value. Compare your calculated ratio to the ratios listed in your data table above. 2) Where does your calculated solar ratio fit in relation to the high and low ratios found in the ACE data for the solar wind?

	3) For the elements H, He, O, and Fe, compare the relative abundance (% by mass) of each as found in the Earth and in the Sun and in the solar wind. List the five most abundant elements found in each. What might account for the values that you observe? GT Connection: Read *ACE News #27 December 21, 1998 Copper and Zinc Isotopes Resolved in CRIS.* Available: http://www.srl.caltech.edu/ACE/ACENews/ACENews27.html Discuss with students: 1) Which element abundances (measured by the ACE/CRIS instrument) are being compared to their abundance in the solar system? 2) According to the news article are these element abundances more or less abundant than iron in the cosmic rays? Support your answer with specific numerical comparisons. 3) According to the news article how do these element abundances compare with all other elements with atomic numbers (Z) greater than 30? Support your answer with numerical comparisons. Career Connection: Research career opportunities with the space program. *NASA Job Information...*Available: http://www.nasajobs.nasa.gov/jobs/jobs.htm 1. Discuss the career opportunities available in Earth/Space science. 2. What are the education requirements related to different categories of opportunities?
EVALUATE	1. As compared with the Sun and the solar wind, is the Earth representative of the matter found through the rest of the universe? Support your answer with numerical comparisons. 2. Describe how technologies used to study the universe provide data for understanding the formation of the solar system and galaxy.

Earth/Space Systems Science
Unit 6: The Biosphere

Materials:
Computer with Internet access, and a scientific calculator

Resources:

Credit:

This lesson is based on the NASA Ambassador Investigation, *Comparing Elemental Abundance.* Available: http://edmall.gsfc.nasa.gov/99invest.Site/ACE/CoElAb.abstract.html
Goddard Space Flight Center Earth and Space Sciences Education Project (GESSEP)
Principal Investigator: Steve Gilligan. Co-Investigator: Vern Smith
Written by Daniel Hortert, GESSEP Program, and Bennett Seidenstein, GESSEP Program. Dr. Eric R. Christian is the ACE Deputy Project Scientist and Beth Jacob is the ACE Outreach Specialist.

Advanced Composition Explorer (ACE) Mission Overview. Available:
http://www.srl.caltech.edu/ACE/ace_mission.html

ACE News #27 December 21, 1998 Copper and Zinc Isotopes Resolved in CRIS. Available:
http://www.srl.caltech.edu/ACE/ACENews/ACENews27.html

ACE Project Page. Available:
http://helios.gsfc.nasa.gov/ace/ace.html

Introduction to Multiplication and Division by Logarithmic Algebra. Available:
http://mentor.lscf.ucsb.edu/mcdb108a/tw-lig/logarithmic-algebra.htm

NASA Educational Brief: Fusion & Nucleosynthesis. Available:
http://edmall.gsfc.nasa.gov/99invest.Site/science-briefs/ace/ed-fusion.html

*NASA Job Information...*Available:
http://www.nasajobs.nasa.gov/jobs/jobs.htm

Lesson 4: Where's Phyto?

Estimated Time: Two to three forty-five minute class periods

Indicator(s) Core Learning Goal 1:

1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions.

1.5.4 The student will create and/or interpret graphics (scale drawings, photographs, digital images, etc.).

Indicator(s) Core Learning Goal 2:

2.1.1. The student will describe current efforts and technologies used to study the atmosphere, land, and oceans of the Earth.
At least – remote sensing from space, undersea exploration, seismology, weather data collection

2.3.1. The student will describe heat transfer systems in the atmosphere, on land, and in the oceans.
At least – convection, conduction, radiation from space and from within Earth

2.5.1. The student will investigate various physical cycles found in the natural world.
At least – rock cycle, water cycle, tides, lunar phases, eclipses, seasons

Student Outcome(s):

1. The student will be able to diagram the interrelationships between phytoplankton and changes in the environment by interpreting composite data images.

2. The student will be able to explain how the cause of seasons impacts various regions of the biosphere.

Brief Description:

Ocean color data from the Coastal Zonal Color Scanner, and SeaWiFS, and temperature data from the Multi Channel Sea Surface Temperature data set will be analyzed to determine the effects of light and temperature on phytoplankton population.

Background knowledge / teacher notes:

For background information on phytoplankton, refer to Where's Phyto? An Investigation of Phytoplankton in the Marine Biosphere. *Background.*
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/trl/inv3-0.abstract.html#inv3-0.background

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Lesson Description:

ENGAGE	Have students to look at the composite image of the Earth. *Ocean Color From Space Global Biosphere*. Available: http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/ocdst_global_biosphere.html . Explain to students that the image is a "composite" of thousands of images from SeaWiFs. Ask them to speculate on the reason for the colors on the land and in the water. Have students brainstorm a list of factors that may impact on the growth of phytoplankton. (Students may refer back to lesson 1 in this unit). Ask students what the impact of the seasons and the sun's angle of incidence might be. Be sure students have a good understanding of why we have seasons. *Accommodation: A model of the sun and Earth may be useful when explaining if students do not have a good understanding of why we have seasons.*
EXPLORE	Be sure students understand the importance of phytoplankton as a source of food for marine life, and the role that the chlorophyll has in the phytoplankton has in the absorption of energy from the sun. Prepare the students for this activity by discussing these questions before students begin. 1. What does the notation, mg/m^3 mean? 2. How would you estimate the number of organisms you would need in order to extract 1 mg of the pigment chlorophyll from phytoplankton? 3. The m^3 indicates a cubic meter of water. Visualize how much space that would occupy. *Accommodation: This could be accomplished with students forming a cube with square meter sheets of paper.* 4. Given that each organism is 10-20 microns in diameter (1 micron = 10^{-6} meters), visualize how many phytoplankton would exists in 1 m^3? 5. What factors do you think would influence the distribution of 0.1 mg in a m^3 of seawater?

	6. How does the angle of incidence of light from the sun affect the amount of heat energy that is received on Earth? 7. How is the tilt of the earth and the seasons related to the angle of incidence and heat energy received on Earth? Have students complete the investigation, *Where's Phyto*? *An Investigation of Phytoplankton in the Marine Biosphere.* http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/trl/inv3-0.html) Have students start with Procedure. This text interacts with students by posing rhetorical questions.
EXPLAIN	***Journal Write***: Examine the images of the four seasonal averages. 1. Where do you see concentrations of phytoplankton located in each season? 2. During the time of highest phytoplankton population, is the angle of incidence of sunlight high or low? 3. In these images, red, yellow, and green indicate higher concentration of chlorophyll. Overlay graph paper on the screen to estimate (in mg/m^3) the combined areas covered by these colors in the Jan-Mar composite. GT Connection: use an image processing software application, such as NIH Image, to do a precise pixel count for each color 4. Do the same for the April - June composite. 5. What areas seem to thrive regardless of season? 6. What conclusions can you state about phytoplankton growth under varied conditions of light?
EXTEND	Multicultural Connection: Regional Studies Go to Nimbus 7 Geographic Regions Maps to view the map of South America. *SeaWiFS Project Nimbus-7 Coastal Zone Color Scanner Data*. Available: http://seawifs.gsfc.nasa.gov/SEAWIFS/IMAGES/CZCS_DATA.html Identify areas of heavy plankton concentration by describing the characteristics of this geographic region. (Refer to World map for additional help) ***Journal Write***: 1. Are these areas close to the Equator or close to the South Pole? What conclusions can you draw from these observations?

	2. Repeat this procedure for the Mediterranean Sea and the North Sea. 3. Which of these areas is closest to the Equator? Which has the largest concentration of phytoplankton? 4. What conclusions can you draw from comparison of the two areas? 5. Explain how sea temperature affects phytoplankton concentration? Continue research with data from a current mission that is studying ocean color, go to the SeaWiFS home page and use the interactive image screen to see new data gathered since September 1997. *Coastal Zone Color Scanner Interactive Region Selection*. Available: http://seawifs.gsfc.nasa.gov/seawifs_scripts/czcs_subreg.pl Choose a zoom factor of 6. Select a box of 1 X 1. Place cursor on the west coast of Africa and click. ***Journal Write***: 1. What do you suppose the average water temperature would be at this latitude? 2. Describe the phytoplankton concentration. Is the phytoplankton concentration consistent with your findings from the previous investigations? Use the same procedure to check other equatorial regions. 3. Propose a hypothesis for the data that you find. Assign lab groups the following regions and summarize the data on the chalkboard or database: the Arctic, Antarctica, Australia, the Indian Ocean, and the Northwest and Northeast Pacific regions. *Accommodation: The teacher can model this process using one of the regions.*
EVALUATE	***Journal Write:*** 1. Create a systems diagram that illustrates the factors that influence growth of phytoplankton. 2. Complete a chart which lists each of the regions of the world you explored and list the factors that would support or limit phytoplankton growth. *Modification: The teacher could provide a bank of factors. Students would select factors appropriate to their region.* 3. Explain how the cause of seasons impacts various regions of the biosphere.

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Materials:
Internet-capable computer, graph paper, world atlas

Resources:
This lesson is based on the NASA Ambassador Investigation, *Where's Phyto? An Investigation of Phytoplankton in the Marine Biosphere*. Available:
http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/trl/inv3-0.html
Goddard Space Flight Center Earth and Space Sciences Education Project (GESSEP)
Principal Investigator: Steve Gilligan. Co-Investigator: Vern Smith
Credits: Carolyn Ossont, Principal Investigator
David Kistler, David Hixson, and Lisa Taschenberger.
Editor: Farzad Mahootian. Scientist: Gene Feldman

Earth/Space Systems Science
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Lesson 5: Seasonal Impact on World Climate

Estimated Time: Two forty-five minute class periods

Indicator(s) Core Learning Goal 1:

1.2.3 The student will formulate a working hypothesis

1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions

1.4.8 The student will use models and computer simulations to extend his/her understanding of scientific concepts

1.5.1 The student will demonstrate the ability to summarize data (measurements/observations)

1.6.2 The student will use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.

Indicator(s) Core Learning Goal 2:

2.5.2. The student will analyze the effects of natural cycles on human activity.
At least – weathering, erosion and deposition, agriculture, aquaculture

Student Outcome(s):

1. The student will be able to compare seasonal climate data by using data visualization software.
2. The student will be able to hypothesize the effect of seasonal change on the biosphere.

Brief Description:

In this activity, students will analyze seasonal climate data by using the computer software application WorldWatcher.

Background knowledge / teacher notes:

The computer software application WorldWatcher must be downloaded and installed on the server in advance of your lesson with the applicable files. (Free but the software must be registered and the process is time consuming.

Students will complete the introductory tutorial, *First-timer Seasonal Activity*

To access the activity:

· Run the **WorldWatcher** program.

- On the title screen, and then click on the *Activities* button to get a menu.
- Double click on *Additional Climate Activities*.
- Open the *First-timer Seasons Activity*

You may need to show students how to move between several windows on the computer.

Students will need a blank map (should be downloaded in advance) and colored pencils for the fall and spring prediction in the Extend activity.

Lesson Description:

ENGAGE	Ask student to hypothesize about the effect of a global increase in temperature on life on the Earth. Prepare students for the activity by discussing the background items: ▪ Incoming solar radiation ▪ Watts/m^2
EXPLORE	Begin the activity. *Examining Seasonal Change through Scientific Visualization*. First-timer Seasons Activity. Students will first open a file that shows incoming solar radiation for January of 1987. Have students use the cursor to determine what kind of information may be accessed from the image. 1. Click on the image under Step 2 for July 1987 incoming solar radiation. 2. Compare the July image to the January image and respond to the questions. 3. Use a blank map and colored pencils to predict the March and September incoming solar radiation.
EXPLAIN	***Journal Write***: 1. Compare incoming solar radiation for January and June. 2. Explain how your prediction maps for March and September fit the data provided in the images.
EXTEND	Open the image map for July 1987 surface temperature. ***Journal Write***: 1. Compare data within the Northern and Southern Hemispheres- is it uniform or variable? 2. Compare data between the two hemispheres.

	3. Now compare incoming solar radiation to surface temperature. Describe your findings. Follow directions under Step 5 to examine average temperatures during the seasons. ***Journal Write***: 1. Complete the chart as indicated for average temperature by month. 2. According to the data, which hemisphere has a warmer temperature throughout the year? 3. According to the data, on average, which month is the Earth's average temperature highest? Follow directions under Step 6 to compare July and January mathematically and create your own visualization
EVALUATE	*Journal Write*: 1. Use the data you have examined to describe the differences in the Earth's climate according to season. Use what you know about why we have seasons to explain the data. 2. Create a systems diagram to relate the factors that cause seasons, climate, and the effect of seasonal changes on the biosphere.

Materials:
Computer with monitor and printer
Blank maps
Set of colored pencils per group

Resources:
Computer program: *WorldWatcher.* Available:
http://www.worldwatcher.nwu.edu

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Lesson 6: Greenhouse Gases and Climate

Estimated Time: One to two forty-five minute class periods

Indicator(s) Core Learning Goal 1:

1.4.1 The student will organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title).

1.4.6 The student will describe trends revealed by data

1.5.3 The student will produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.

Indicator(s) Core Learning Goal 2:

2.3.3. The student will research topics of current concern with regard to climate.
At least – greenhouse effect, global warming (or cooling), ocean currents

2.5.2. The student will analyze the effects of natural cycles on human activity.
At least – weathering, erosion and deposition, agriculture, aquaculture

Student Outcome(s):

1. The student will be able to relate temperature changes to gas level changes by analyzing graphed data.
2. The student will be able to explain the effect of human activity on the amount of greenhouse gas in the atmosphere, and its effect on the Earth's climate.

Brief Description:

Students will read a technical document and then analyze archived data to determine if there is a relationship between carbon dioxide level and temperature. Students will then explain what they have learned about greenhouse gases by assuming the role of a reporter and writing a newspaper article to inform the general public.

Background knowledge / teacher notes:

Global temperature correlates with the concentration of greenhouse gases. Both have increased during the 150 years or so that humans have been putting these gases into the atmosphere. However, both temperature and gas concentration have fluctuated together for thousands of years, be-

fore humans could have had much effect. Humans may be causing the present rise in temperature, but not all temperature changes are caused by human activity.
Reprinted from Athena Atmospheric Earth. *Atmospheric Greenhouse Gases*. Available: http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html#sum

Discuss with students the complexity of the Earth's systems and the difficulty of predicting the consequences of human action on those systems. Scientists do not yet have enough reliable data over a long enough period of time to enable them to draw any reliable, substantiated conclusions. Prevent students from jumping to any conclusions based on the small data sets studied in this activity. Be sure to have them differentiate between a hypothesis and a conclusion.

Lesson Description:

ENGAGE	Have students read *How do Greenhouse Gases Make it Warmer?* Available: http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html ***Journal Write***: create a concept map that includes the important ideas from the reading. Have student groups share their concept maps. *Accommodation: If students had copies of the reading, they could highlight important ideas they want to include in the concept map.*
EXPLORE	Have students read *How do Greenhouse Gases Make it Warmer?* Available: http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html ***Journal Write***: Create a concept map that includes the important ideas from the reading. Have student groups share their concept maps. Discuss the meaning of each of the graphs included in the document: · Mauna Loa Mean Monthly Carbon Dioxide · NOAA CMDL Methane Measurements · Changes of temperature from a reference level (average of the most recent 30 years) Analyze the relationship of past CO_2 levels and temperature data by constructing a graph that plots CO_2 and temperature. Plotting *CO_2 and Temperature*. Available: http://www.athena.ivv.nasa.gov/curric/land/global/plotco2.html 1. Make a table to show the difference in temperature from the base-

	line (anomaly), and the concentration of CO_2 back to 1860. Assume that the pre-industrial temperature (before 1800) was the same as it was in 1860. 2. Use the second paragraph in *Sources and Losses of Greenhouse Gases*. Available: http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html#source to find the pre-industrial level of CO_2. 3. Data are in the technical reading *Atmospheric Gases*. Available: http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html 4. Label the vertical scale 200 to 400 ppm (parts per million) of CO_2. 5. Place the zero of the horizontal scale in the middle, and label it -1 to +1 degree centigrade, using tick marks every 0.1 degree. The middle of this scale corresponds to the reference line of average temperature in the figures showing temperature versus time. 6. Use the table of temperature and CO_2 to plot the temperature and carbon dioxide for each year. You should have data from 1800 to 1995, and should see a scatter of points sloping upward to the right. 7. Draw a line through the center of the points and extend it straight to the lower left.
EXPLAIN	***Journal Write***: Analyze the graph by considering the following questions. 1. What was the CO_2 content when the temperature was four degrees lower, during an ice age? You will have to extrapolate using a straight line. Does this give a sensible result? If the amount of CO_2 is negative, either the straight-line relationship between temperature and CO_2 is wrong, or other effects must have cooled the earth at that time. 2. How much CO_2 must there be to raise the temperature seven degrees a hundred years from now, assuming the straight line relationship?
EXTEND	Have students work in teams to report on Greenhouse Gases. *Science Reporting on Greenhouse Gases*. Available: http://www.athena.ivv.nasa.gov/curric/land/global/scirep.html

	You are the newspaper science reporter for the Honolulu Daily. Your assignment is to go out to the Mauna Loa Observatory and report on their research on the greenhouse effect. As usual, you have the challenge of explaining science to non-scientists. Your report must include the following: 1. An explanation of the suspected greenhouse effect. 2. A description of the types of research being done. 3. The types of gases involved and their sources. 4. The trend of the gas levels over the past 250 years. 5. The trends of the temperatures over the past 250 years. 6. A graphic to illustrate the article. *Accommodation: This information could also be communicated using a television new show format with a student interviewing an 'expert' of the subject of the greenhouse effect.*
EVALUATE	Create a systems diagram that illustrates the relationship of greenhouse gases, human activity, and climate.

Materials:
Internet-capable computer, graph paper and pencil, spreadsheet computer program (optional)

Resources:
Credit for this activity: Athena Curriculum Earth. Written by Suzanne Olson.

Atmospheric Gases. Available:
http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html

How do Greenhouse Gases Make it Warmer? Available:
http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html

Plotting *CO_2 and Temperature*. Available:
http://www.athena.ivv.nasa.gov/curric/land/global/plotco2.html

Science Reporting on Greenhouse Gases. Available:
http://www.athena.ivv.nasa.gov/curric/land/global/scirep.html

Sources and Losses of Greenhouse Gases. Available:
http://www.athena.ivv.nasa.gov/curric/land/global/greenhou.html#source

Teachers' Materials for ACTIVITY: Atmospheric Gases. Available:
http://www.athena.ivv.nasa.gov/curric/land/global/tgreen1.html

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Lesson 7: Finding A Balance– The Everglades

Estimated Time: Two forty-five minute class periods

Indicator(s) Core Learning Goal 1:
1.1.1 The student will recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues.

1.1.3 The student will critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.

Indicator(s) Core Learning Goal 2:

2.3.3. The student will research topics of current concern with regard to climate.
At least – greenhouse effect, global warming (or cooling), ocean currents

2.5.2. The student will analyze the effects of natural cycles on human activity.
At least – weathering, erosion and deposition, agriculture, aquaculture

Student Outcome(s):

The student will be able to create an action plan to address drought in the Everglades by examining factors that affect this subsystem of the biosphere.

Brief Description:

Land and People: Finding a Balance is an environmental study project that engages high school students in studying earth science resource issues. The project focuses on the interaction between people and the environment in three regions of the United States: Cape Cod, Los Angeles, and the Everglades. Each section of this project is devoted to one of the three regions. The student will assume a role in a community group to create an action plan that will address the damage that a long period of dry weather will cause to human and ecological interests in the Everglades.

Background knowledge / teacher notes:
The Teaching Guide provides an overview of the project as well as a list of references for teachers, by region. The references cited in this list were used as background information for the sections of the Packet.
The Teaching Guide. Available:
http://www.usgs.gov/education/learnweb/LandPeople/dwnld.html

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The Poster presents a variety of visual images from each region with explanatory text about each one. Use the poster to begin a general discussion about human impact on the environment as well as to discuss the specific consequences of human actions in each region.
The Poster. Available:
http://www.usgs.gov/education/learnweb/LandPeople/pdf/Poster.pdf

Each section contains a set of student materials and a set of teacher materials for Cape Cod, the Everglades, or Los Angeles. Each section is divided into two parts: "For the Student" and "For the Teacher." The student materials present students with a Focus Question to answer and also provide them with several types of information they should use to answer the question. Student materials include some or all of the following:

- a reading about the region
- a description of the "Interested Parties" so students can role-play as they answer the Focus Question
- maps
- population data
- geologic information
- water use data
- photographs

The teacher materials include a brief explanation of what students will learn as they work on answering the Focus Question and a description of what form their answer might take. The teacher materials also present three Activities that will help students answer the Focus Question. Each Activity clearly describes what students will need to complete the Activity, explains the procedure, and in some cases, suggests extension activities. Any maps or other information students will use to complete the Activities are included in the teacher materials.

The sections can be studied in any order. A class could complete all three sections or just one. The sections can be used in whole or in part. Students might read the entire set of student materials for a region then complete all the activities in the teacher materials, or just complete selected activities.

Each student will need a copy of the student materials. These materials are designed to be photocopied clearly and easily. Students will also need copies of the maps and other data that accompany the activities in the teacher materials.

This activity requires that students be divided into three “community action” groups. Rather than have three large groups, you may want to divide your students into smaller groups and have multiple community groups researching the same area.

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The following is from *The Everglades: River of Grass* by Marjory Stoneman Douglas (1947).

"There are no other Everglades in the world. They are, they have always been, one of the unique regions of the earth, remote, never wholly known. Nothing anywhere else is like them: their vast openness, wider than the enormous visible round of the horizon, the racing free saltness and sweetness of their massive winds, under the dazzling blue heights of space. They are unique also in the simplicity, the diversity, the related harmony of the forms of life they enclose. The miracle of the light pours over the green and brown expanse of saw grass and of water, shining and slow-moving below, the grass and water that is the meaning and central fact of the Everglades of Florida. It is a river of grass...Where do you begin? Because, when you think of it, history, the recorded time of the Earth and of man, is in itself something like a river. To try to present it whole is to find oneself lost in the sense of continuing change. The source can be only the beginning in time and space, and the end is the future and the unknown... So it is with the Everglades, which have that quality of long existence in their own nature. They were changeless. They are changed."

Lesson Description:

ENGAGE	The year is 2010. The National Weather Service has studied the last decade's rainfall rates and the storm patterns over the Atlantic Ocean and has produced an alarming forecast: over the next 5 years, the Everglades- region will experience a 30-percent- decrease in the amount of rainfall it receives. But lack of rainfall is not the only challenge that the Everglades faces. During the last century, increasing urban and agricultural activity has profoundly changed the Everglades. Humans have drained the wetland and created a complex canal and levee system, causing drastic changes in the ecosystem: shrinking populations of wading birds and the collapse of alligators' nesting activities. How will your group respond to this serious decrease in rainfall? Create an action plan that will reduce the damage the long period of dry weather will cause to human and ecological interests. From USGS. Land and People. Finding a Balance. Everglades. *Focus Question.* Available: http://www.usgs.gov/education/learnweb/LandPeople/everstud.html *Accommodation: Directed reading of selected sections of this background information will be necessary. If students had printed copies, important information could be highlighted.*
EXPLORE	Divide the class into three community groups: · environmental activist · agribusiness/farmer · urban development Each group will develop and propose an action plan that will reduce the damage the long period of dry weather will cause to human and ecological interests. Direct students to the above Website to conduct their research: http://www.usgs.gov/education/learnweb/LandPeople/everstud.html Scroll down to the section addressing "The Interested Parties." Each group should read the section that concerns them. Students should then explore the rest of that web page, looking for information their group can use to develop their action plan.

EXPLAIN	***Journal Write***: Have students develop a visual aid that can be used to illustrate the critical points of their presentation.
EXTEND	The class should establish a set of criteria for judging the action plan. Have students hold a community forum and present their action plan and supporting evidence to the other groups in their community.
EVALUATE	***Journal Write***: 1. Create a systems diagram that illustrates the interrelationship of factors in the Everglade subsystem. 2. Explain how your action plan accounts for the variety of factors affecting the subsystem that is the Everglades.

Materials:
Internet capable computer, chart paper and pens and other materials for "Extend" and a map of the Everglades and surrounding area.

Resources:
Poster. Available:
http://www.usgs.gov/education/learnweb/LandPeople/pdf/Poster.pdf

Teacher' s Guide. Available:
http://www.usgs.gov/education/learnweb/LandPeople/dwnld.html

USGS. Land and People. Finding a Balance. Everglades. Available:
http://www.usgs.gov/education/learnweb/LandPeople/everstud.html

Engage data tables:

Population Growth

County	1980	1990	Net Change in Number	Net Change in Percent
Broward	1,018,257	1,255,488	+237,231	+23.3
Dade	1,625,509	1,937,094	+311,585	+19.2
Palm Beach	576,758	863,518	+286,760	+49.7

Which county gained the most people between 1980 and 1990?
Which county gained the largest percentage of growth during that period?

Projected Range of Public Supply Water Use Per Day
(in millions of gallons)

County	2000	2010	2020
Broward	257.4	285.4	316.2
Dade	395.8	425.5	471.4
Palm Beach	253.1	305.0	338.0

Which county has the slowest rate of projected use of public water? (To answer this question, subtract the figure for 2000 from the figure for 2020.)

Total Freshwater Withdrawn Per Day
(in millions of gallons)

County	1965	1970	1980	1990
Broward	173.13	184.35	235.58	266.53
Dade	287.80	276.47	440.45	490.55
Palm Beach	414.50	504.38	752.71	996.84

Palm Beach County's use of freshwater more than doubled between 1965 and 1990. Did Palm Beach County's population grow at about the same rate?

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Lesson 8: Analyzing a Subsystem of the Biosphere as an Earth System

Estimated Time: Two plus forty-five minute class periods

Indicators(s): Core Learning Goal 1

1.5.3 The student will produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.
1.5.9 The student will communicate conclusions derived through a synthesis of ideas.
1.7.1 The student will apply the skills, processes, and concepts of biology, chemistry, physics, and earth science to societal issues.

Indicators(s): Core Learning Goal 2

2.2.2. The student will explain the role of natural forces in the earth.
At least – retention of an atmosphere, an agent of erosion and deposition, tides and deep ocean currents
2.3.2. The student will investigate meteorological phenomena
At least – hurricanes, tornadoes, floods, thunderstorms, blizzards
2.3.3. The student will research topics of current concern with regard to climate.
At least – greenhouse effect, global warming (or cooling), ocean currents
2.8.3. The student will use tables, charts, and graphs in making oral and written presentations.

Student Outcome(s):
The student will be able to analyze a specific subsystem of the biosphere and how it relates to other Earth systems by creating a systems diagram.

Brief Description:
Students will choose a Biosphere Reserve as an area for investigation by choosing from the more than 368 sites in 91 countries listed in the *WORLD NETWORK OF BIOSPHERE RESERVES.*
Available: http://www.unesco.org/mab/wnbr.htm
Students will construct a systems diagram of the biotic and abiotic factors making up their Biosphere Reserve. Students will then expand the diagram to show how the other Earth systems relate to the Biosphere subsystem.

Some key factors to consider in the analysis:

- tides
- ocean currents
- meteorological phenomena (such as hurricanes, tornadoes, floods, thunderstorms, blizzards)
- weather/climate interactions and climate anomalies
- metamorphism, weathering, erosion, deposition, melting, crystallization
- rock cycle, water cycle, tides, lunar phases, eclipses, seasons
- agriculture, aquaculture

- plate tectonics, sea floor spreading, faulting, earthquakes, and volcanoes
- current efforts and technologies used to study the atmosphere, land, and oceans
- convection, conduction, radiation from space and from within Earth
- energy reserves

Also:
1. How is the amount of life supported affected by the availability of resources in the Biosphere Reserve?
2. How have human activities and technology changed the Biosphere Reserve?
3. How do processes in the Biosphere Reserve affect humans?

Background knowledge / teacher notes:
Biosphere Reserves are areas of terrestrial and coastal ecosystems that are internationally recognized within the framework of UNESCO's Man and the Biosphere (MAB) Program. Collectively, they constitute a World Network. They are nominated by national governments and must meet a minimal set of criteria and adhere to a minimal set of conditions before being admitted into the World Network.

Biosphere Reserves serve many purposes. Among the purposes are:

To conserve biological diversity.
Human pressures on land and water resources are drastically reducing the diversity of genes, plant and animal species, ecosystems and landscapes of the planet. This threatens human welfare, since this biodiversity is the potential source of foods, fibers, medicines, and raw material for industry and building. It constitutes an irreplaceable wealth for research, education and recreation for the whole of humankind. The core areas and buffer zones of Biosphere Reserves serve as repositories to safeguard samples of the biodiversity of the world's major biogeographical regions, and as reference and study sites to help improve our knowledge on biodiversity.

To maintain healthy ecosystems.
Biosphere reserves, which may represent large areas of land and water, contribute significantly to the maintenance of the life support systems which serve to avoid soil erosion, maintain soil fertility, regulate river flow, recharge aquifers, recycle nutrients, and absorb air and water pollutants.

To learn about natural systems and how they are changing.
Research may be conducted on the structure and dynamics of the minimally disturbed natural systems of the core areas of Biosphere Reserves, and compared with the functioning of human-affected landscapes in the buffer and transition areas. Such studies, when carried out over the long term, show how these systems may be changing over time. Setting up similar long-term monitoring plots, and harmonizing methods and measurements allows comparison of results regionally

and worldwide. The information thus obtained allows us to better understand global environmental changes.

To learn about traditional forms of land-use. People in many parts of the world have devised, over a long period of time, ingenious land-use practices which do not deplete the natural resources and which can provide valuable knowledge for modern production systems. Biosphere Reserves are areas where such peoples can maintain their traditions, as well as improving their economic well-being through the use of culturally and environmentally appropriate technologies. Moreover, such traditional systems are highly useful for conserving ancient breeds of livestock and old land races of crops, which are invaluable gene pools for modern agriculture.

To share knowledge on how to manage natural resources in a sustainable way. Research to find land-use practices that improve human well-being, without degrading the environment, is a central purpose of Biosphere Reserves. The lessons learned are transmitted at the field level through on-the-spot training and demonstrations. They can then be applied in the transition area and in the region beyond. Government officials, national and foreign scientists, visitors, as well as local community leaders, all benefit from this experience. The Biosphere Reserve thus serves to share knowledge and skills at the local, national and international levels.

To co-operate in solving natural resources problems.
A major obstacle to reconciling environment with development is the sectoral structure of our institutions. Biosphere Reserves provide places where conflicts in interest can be debated by all the stakeholders concerned: local officials, local landowners, nature conservation associations, government leaders, scientists, local farmers, fishermen, private enterprises, etc. all must work together to find appropriate co-ordination mechanisms to plan and manage the Biosphere Reserve. Biosphere Reserves therefore provide opportunities for conflict resolution that could be applied in other land and water development issues.

From: *Why do we need Biosphere Reserves?* Available:
http://www.unesco.org/mab/brfaq-2.htm

Lesson Description:

ENGAGE	Ask student to suggest reasons for countries to designate areas of land to be "biosphere reserves." Ask students to read *Why do we need Biosphere Reserves?* Available: http://www.unesco.org/mab/brfaq-2.htm and then add to the list of reasons. The descriptions in this reading will serve to provide suggestions for interactions later in the activity.

EXPLORE	Ask students to work in teams to investigate a Biosphere Reserve of choice or one that the teacher has assigned. *WORLD NETWORK OF BIOSPHERE RESERVES*. Available: http://www.unesco.org/mab/wnbr.htm An alternative to choosing a Biosphere Reserve from the United Nations Resource is to select an urban area that students must research. This would be more challenging to the student and more time would be required. The class should set a list of criteria by which the presentations will be evaluated before the work begins. Include the following questions as part of the criteria: 1. How is the amount of life supported affected by the availability of resources in the Biosphere Reserve? 2. How have human activities and technology changed the Biosphere Reserve? 3. How do processes in the Biosphere Reserve affect humans? Multicultural Connection: With representation from over 91 countries and 368 different sites, this is an excellent opportunity to integrate science knowledge with knowledge of another world culture. Students should review all of the information included in the Biosphere Reserve profile. Some sites offer a sparse amount of information and other sites offer a great deal of information. Students should select a site that offers a substantial amount of information in order to create their systems analysis.
EXPLAIN	***Journal Write***: Once the particular Biosphere Reserve has been chosen, students will describe their particular area of study. Students will build a concept map, systems diagram, or other type of graphic organizer that is a graphic representation of their Biosphere Reserve. Starting points of the description or presentation should include: ▪ Type of Ecosystem ▪ Habitats ▪ Organisms ▪ Location (find on world map) ▪ Principal research activities

	▪ Physical description Some students may wish to begin by listing the biotic and abiotic factors and then expanding from those factors. A list of key factors is included in the Teacher Notes. The teacher may wish to share these ideas with the class if they come to a point where they need assistance. The list above is not meant to be a limiting one. Many of the descriptions include an e-mail address for a point of contact. This may be a vehicle for obtaining further information about the Reserve or students may do some limited internet research. *Accommodation: The teacher should model the process throughout this lesson. He/ She could model the process using a biosphere reserve not selected by any of the students.*
EXTEND	Once students have gathered information they will use the information they have learned from studying the atmosphere, hydrosphere, geosphere, and perhaps the space sphere to construct a more in-depth systems diagram. The systems diagram should show ways that each of the spheres interrelates with the Biosphere Reserve they have chosen.
EVALUATE	Students will share their systems diagrams with other groups. A peer discussion and constructive comments will allow students in the class to add to the detail of the systems diagrams. ***Journal Write***: 1. Explain the interactions of your systems diagram by writing a description in your journal. 2. What questions arise from your analysis? 3. How is the amount of life supported affected by the availability of resources in the Biosphere Reserve? 4. How have human activities and technology changed the Biosphere Reserve? 5. How do processes in the Biosphere Reserve affect humans? 6. What other research areas would you suggest to the Biosphere Reserve personnel? <u>GT Connection</u>: Create a proposal for further investigation based on the analysis you have completed. Include science goals and a science rationale, a budget, equipment and materials, personnel, and a time frame for completion of your proposed project.

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Materials:
Internet capable computer
Presentation software
World map

Resources:
WORLD NETWORK OF BIOSPHERE RESERVES. Available:
http://www.unesco.org/mab/wnbr.htm

Why do we need Biosphere Reserves? Available:
http://www.unesco.org/mab/brfaq-2.htm